Development of a Management and Assessment Program for Transmission Pipelines (PIPELINE CAIRS MODEL)

This study was funded by the Minerals Management Service, U.S. Department of the Interior, Washington, D.C., under contract Number 14-35-001-30629

1) Executive Summary

1.1) Background

Assuring the continued safe operation of petro-chemical transmission pipelines is an issue that is growing following some recent highly publicized accidents. The Minerals Management Service (MMS) in conjunction with the Department of Transportation (DOT) is facing the problem of having to review performance of more than 470,000[1] miles of transmission pipelines in the USA. Maintaining inspection and maintenance records is important to the MMS, DOT and the pipeline operators alike.

1.2) Scope of Work

At the solicitation of the Minerals Management Service (MMS), OCEANEERING - SOLUS SCHALL initiated a research and development project to investigate the feasibility of producing a dedicated Computer Aided Inspection Reporting System (CAIRS) for petrochemical transmission pipelines.

The intent of the project was to provide the following:

A standardized data collection and reporting format that may be used by the pipeline operating companies.

A working model of a database for the storage and manipulation of simulated pipeline inspection information.

2) System Overview

2.1) Introduction

At present, Operators have many different systems for the collection, evaluation and storage of data relating to the structural integrity of their pipelines.

Operators are using both manual and custom computerized systems, the amount and quality of the data collected varies widely from operator to operator and this produces a pool of information which unfortunately requires complex evaluation in order to produce comparable and therefore useful results.

This information pool also contains statistical information useful in predicting the safe operating limits and life expectancy of the pipelines, but unfortunately this information is not effectively collected, analyzed and utilized at the moment.

The aim of this research project was to produce a standardized system of the collection, storage and retrieval of pipeline data. This system being a vehicle for the data which can later be evaluated and analyzed by statistical methods. The intent being to help provide more efficient exploitation of oil and gas resources while affording greater protection to personnel and the environment.

2.2) Standardized Data Collection Forms

Oceaneering - Solus Schall through it's many operating offices worldwide solicitated input on the type and quantity of data collected for typical pipeline inspection. The type of information collected was found to be fairly uniform worldwide. The quantity and quality of information collected varied considerably on a job to job basis, with automated methods (Remote Monitoring or Robotic Systems) generating the greatest quantity of data. This data is normally available in an electronic format that CAIRS can potentially import.

Land pipelines and offshore lines inspected by divers and by video via Remotely Operated Vehicles (ROV's) will require a paper form to be completed when direct data entry into the computer is not available or impractical.

Appendix A details a collection of standardized data forms produced in conjunction with this study.

2.3) Working Model of a Database

Our investigations worldwide along with over ten years experience of producing computerized Inspection, Maintenance and Repair (IMR) systems for the petro-chemical industry has enabled Oceaneering - Solus Schall to produce a working model of a Computer Aided Inspection Reporting System (CAIRS) for transmission pipelines, the software being able to store, search and manipulate construction and inspection data for both onshore and offshore pipelines. The system was designed to allow the user to access and evaluate the data via stand alone statistical evaluation programs.

The intent was to provide industry with a standardized method of collecting, storing and exchanging data relating to transmission pipelines. With this standardized system of storage, the global analysis of the data becomes possible.

2.3.1) System Concepts and Details

The working model was designed as a tool to collate and assimilate the large volumes of inspection data in order to provide accurate and timely information for the engineer. As the name implies, CAIRS requires data from ongoing inspections so as to allow analysis. The interpretation of current data in a historic context is vitally important as it is only through this, that accurate assessment of conditions can be made.

By using CAIRS to screen data for potential problems, the possibility of missing a critical piece of information is reduced. Consequently, by relieving engineers of the tedious task of checking and analyzing each item of data, they are in the position to spend more time preparing remedial programs and future inspection programs. These productivity gains mean that tasks that were previously thought impossible through the constraint of time and/or resources may now become achievable.

With improving computer technology and a desire on behalf of operators for more exacting inspection monitoring standards it has becoming increasingly apparent that this principal system objective has now changed from that of a paper based reporting system to that of a system which collates and reports inspection information on electronic media (computers). Obviously the management effort involved in assessing a large volume of paper reports associated with IMR activities was and is becoming prohibitive. Computerized Inspection systems should therefore be focused on producing summary and non-conformance reports as well as producing reports that present all data collated in the course of a given inspection.

2.3.2) Methodology

It is known that users of inspection packages of this kind have varying requirements. This is because by different regulations and objectives by different operators in different geographic regions.

CAIRS has therefore been written with this requirement for change and evolution as one of it's important objectives.

CAIRS achieves this objective by allowing the user to set up his own environment, in that he can specify the nature and extent of validation and cross checking. Amongst other benefits this allows the user to specify his own acceptance criteria for the data, thus providing a fast and flexible means to process data for non-conformance.

The primary purpose of Pipeline CAIRS is to assist engineers and technicians in the compilation and interpretation of inspection results.

Data is typically entered into the system manually, however the nature of Pipeline Inspection means that the system will largely be concerned with data which in itself is generated by a computerized data logging system. Since this data is available in ASCII format, CAIRS has been given the ability to import and screen this data directly from this media without the need for manual intervention.

2.3.3) Data held in the System

The data in the Pipeline system can be grouped into the following categories.

2.3.3.1) Pipeline Master Records

This data relates to information that can be directly attributed to the pipeline as a whole. This would typically include details specific to a given pipeline such as types of pipeline coatings used, and the anodes installed.

2.3.3.2) Inspection Master Records

This data is concerned with Inspection Events or Surveys. This is mainly confined to summary data such as the type of inspections, who performed it and when was it carried out. The system also has the facility to associate many pipelines against a given Inspection Master Record.

2.3.3.3) Components

Components comprise several data categories, each of which holds descriptions of the physical features, installed items or abnormalities that can be inspected on or around the pipelines. Each of these data categories holds data for a specific type of feature, eg anodes. The system also has the ability to relate one component with another (eg. a span with a specific Crossing).

It should be appreciated that these Components are NOT Inspection Specific. Instead they are meant to hold information that can be referenced and updated by Inspection data.

2.3.3.4) Inspection Results

As the name suggests, this relates to the observations made during the course of a given Inspection or Survey. These will be associated with both a Master Pipeline record and Inspection Results.

2.3.3.5) Relationships

Each Component is allocated a unique ID number by CAIRS to allow the comparison of results for one object gathered from several Inspections. The identities used will indicate the component type, eg. A = ANODE, C = CROSSING, etc., together with a sequential number. These numbers are NOT related to any positional data (ie. a high ID number does not necessarily mean a high Footpost (FP) position).

In general the data that is considered to be descriptive and constant from inspection to inspection is held in the Component data tables.

All other data is held under Inspection results - both in the data table that is specific to that category of Component eg Crossing, Anodes, etc., and in the general results data tables, eg. Photographs, CP etc.

All Components regardless of source are listed in the Master Component Inventory list which will allow you to see the order (by Footpost) in which the items appear along the pipeline.

Components are created by one of two methods. In both instances the ID number is allocated by CAIRS. Once allocated you cannot reassign a number.

Method 1
By direct data entry, eg. when a crossing is installed on a pipeline, the necessary information can be entered prior to the next survey of that line.

Method 2
Related to the discovery of events during a survey. When you enter an inspection result that has a related Component Category (eg. Anodes) the system will check to see if this component already exists on the system - if not it will provide the option to create a new one. In the event that data is being imported via text files, the system will automatically create new Components if it cannot find a preexisting component. The system can "find" a component from an inspection record by checking if there is a component of that type within the vicinity of the Footpost position you have specified in the inspection record. The extent of this search that defines the term "vicinity" is specified by the user in the Pipeline Master Record and would be typically ±17 feet.

2.3.4) Sample Inspection Data

Sample inspection data derived from actual pipeline inspections is included on additional diskettes and can be loaded into the model database. This 'sanitized' data was compiled from pipeline inspections carried out over a number of years offshore in the Middle East and was supplied courtesy of Mr. Alex Lang in Oceaneering's Aberdeen, Scotland office.

2.3.5) Hardware & Software requirements

The database model was designed to work on an IBM PC running under MSDOS version 3.00 or later. The system is network ready and is compatible with all common LAN's (Novell, Microsoft LAN Manager, etc.). Although the system will run on an IBM XT computer the minimum recommended configuration is as follows:

- AT compatible 80386 machine with a 20Mhz clock speed.
- VGA color graphic card.
- 4Mb RAM
- 60Mb Hard disk.

2.3.6) Technical Documentation

Supplied with this report is a copy of the model database on both three and five inch diskettes, and the associated volume of technical information relating to the pipeline CAIRS database design and structure. Note that further copies of this documentation may be generated from the system administration menu of the pipeline system.

INSTALLATION INSTRUCTIONS

PIPELINE CAIRS Version 1.00 is supplied on both high density 3½" and 5¼" diskettes.

Your CAIRS system is supplied in a compressed archived format which allows easy installation and large amounts of data to supplied on a small number of diskettes.

To INSTALL your CAIRS system simply:

1) Place the disk 1 supplied in your floppy drive.

2) Change your drive to the floppy drive (eg. A:)

2) Type INSTALL

Notes:

It is recommend that the your PC has as a minimum, 500k of DOS accessible free RAM before accessing the CAIRS system.

Ensure that a CONFIG.SYS file is resident in the root directory of the primary hard disk (normally drive C:)
The file must contain these commands:

```
files=80
buffers=30
```

Before entering inspection data into CAIRS it is necessary to create the library files that are used for on line validation. The first operation for the CAIRS administrator must be to go to the library maintenance function and enter all the relevant data. Care must be taken to construct an accurate library system as all subsequently inspection data will be validated against this standard. (Note in this package sample libraries are included)

PIPELINE DATA INSTALLATION

To INSTALL the demo data simply:

1) From the drive and subdirectory where CAIRS is located (where the CAIRS.BAT is located) type A:\DATA A: X:

   Where A: is your Floppy drive letter and X: is the letter of the hard drive where CAIRS is located.

After installation of the data, you will need to REGENERATE the CAIRS system before the data can be accessed. From the MAIN MENU of CAIRS select SYSTEM ADMINISTRATION and the SYSTEM Regeneration.

Given the amount of data involved this regeneration of the system may take some time (hrs!), we recommend that the system be left to regenerate overnight.

3) Summary of Final Results

A working model of a pipeline inspection database complete with search facilities was constructed and assembled with over twenty megabytes of actual inspection data and is supplied along with this report.

Standardized data collection forms for pipeline inspection were created and successfully used in practice by Oceaneering personnel.

4) Conclusions Drawn from Results

Computerized inspection systems are the only practical means by which the large quantities of data generated by inspection can be tracked and subsequently evaluated.

Environmental and safety concerns are dictating that the construction and in-service inspection data be fully evaluated to determine the suitability for further service of each individual pipeline. Evaluation to standard engineering codes could be very manpower intensive but would be a suitable candidate for further computerization.

5) Recommendations and Future Research

The database model could be further refined to provide an engineering evaluation of each pipeline segment and subsequently assign a relative risk assessment value to the line. Thus the MMS, DOT or operators of the lines would quickly be able to determine which lines require most attention (the ones with the greater evaluated risk) and also any lines requiring remedial action.

References

1. Estimate by the office of the Pipeline Intelligence Report, Houston TX Feb. 1993

APPENDIX A

PIPELINE DESC./HISTORY	INSPECTION #	PIPELINE ID #	DATE
YR. INSTALLED	CONTRACTOR	SERVICE (O,G,W)	O = OIL G = GAS W = WATER

PIPELINE DETAILS		ANODE DETAILS	
PIPELINE DIMENSIONS:	WALL THICKNESS – LENGTH (X 1000) –	TOTAL NUMBER ORIGINALLY INSTALLED	
NOMINAL O.D. (IN.)		COMPOSITION	
PIPELINE WEIGHT (LB/FT) :		ATTACHMENT METHOD	
CONNECTING PIPE DIMENSIONS:	WALL THICKNESS – DIAMETER –	ANODE DIMENSIONS	LENGTH – WIDTH – THICKNESS –
CONNECTING RISER DIMENSIONS:	WALL THICKNESS – DIAMETER –	ANODE VOLUME (CU. FT.)	
YEAR LAST INSPECTED		ANODE WEIGHT	
STEEL TYPE AND GRADE		DESIGN LIFE	
ANTI-CORROSION COATING TYPE		CURRENT density (mA/FT)	
ANTI-CORROSION COATING THICKNESS		CAPACITY (AMPS/HR/LB)	
WEIGHT COAT THICKNESS		ANODE NO./TYPE	NO. ORIGINAL – NO. RETROFIT –
ESTIMATED % BURIAL (OVERALL)		ESTIMATED % DEPLETION	

COMMENTS

INSPECTED BY:	SAMPLE PIPELINE CAIRS
AUTHORIZED BY:	

WORK HISTORY	INSPECTION #	PIPELINE ID #	DATE

START DATE (MM/DD/YY)	
END DATE (MM/DD/YY)	
SPAN INSPECTED	
LENGTH INSPECTED	
WORK TYPE (REMEDIAL/INSPECTION/INSTALLATION)	
REMEDIAL WORK DESCRIPTION	
CONTRACTOR	
VESSEL(S)/DESCRIPTION	
DIVING TYPE (ROV, AIR, GAS, SAT)	
DIVING DESCRIPTION (EQUIPMENT, NO. DIVERS, ETC.)	
C.P. EQUIPMENT	
C.P. CONTRACTOR	
SURFACE NAVIGATION SYSTEM	
PIPETRACKER	
PROFILER	
WALL THICKNESS EQUIPMENT	
TOTAL PROJECT COST	

COMMENTS:

INSPECTED BY:	SAMPLE PIPELINE CAIRS
AUTHORIZED BY:	

PIPELINE COMPONENTS		INSPECTION #	PIPELINE ID #			DATE	
LOCATION		COMPONENT DESCRIPTION (VALVE, FLANGE, SIDE TAP, ETC.)	C.P. VALUE	PHOTO #	VIDEO #	DRAWING #	COMMENT #

COMMENTS:

LOCATION	FIELD JOINT #	DISTANCE ALONG JOINT	SAMPLE PIPELINE CAIRS	
CODE	SURVEY FIX #	SEA MARK		

PHYSICAL DAMAGE	INSPECTION #	PIPELINE ID #	DATE

DAMAGED COMPONENT – PIPELINE VALVE FLANGE SIDE TAP OTHER

DAMAGE REPORT #	LOCATION			

DRAWING NUMBER			
PHOTO NUMBER			
VIDEO NUMBER			
DAMAGED COMPONENT			
DAMAGE DIMENSIONS	LENGTH	WIDTH	DEPTH
MAX.			
MIN.			
PROBALE CAUSE			
C.P. VALUE			

COMMENTS:

LOCATION	FIELD JOINT #	DISTANCE ALONG JOINT	SAMPLE PIPELINE CAIRS
CODE	SURVEY FIX #	SEA MARK	

COATING DAMAGE	INSPECTION #	PIPELINE ID #	DATE

LOCATION		DIMENSIONS(MAX/MIN) L	W	D	CLOCK POS.	COAT. THICK.	BARE METAL (Y/N)	PHYS. DAM. (Y/N)	DMG. RPT. #	C.P. VALUE	PHOTO #	VIDEO #	DRAWING #	CMMNT #

COMMENTS:

LOCATION	FIELD JOINT #	DISTANCE ALONG JOINT	SAMPLE PIPELINE CAIRS	
CODE	SURVEY FIX #	SEA MARK		

SPAN	INSPECTION #	PIPELINE ID #	DATE

LOCATION		SPAN DIST.(FT)	MAX HEIGHT (FT)	SPAN WEIGHT	SPAN MOVING (Y/N)	DEPTH (T.O.P.)	BOTTOM TYPE	DRAWING NO.	PHOTO #	VIDEO #	CMMNT #

COMMENTS:

LOCATION	FIELD JOINT #	DISTANCE ALONG JOINT	SAMPLE PIPELINE CAIRS
CODE	SURVEY FIX #	SEA MARK	

C.P. SURVEY	INSPECTION #	PIPELINE ID #	DATE
C.P. CONTRACTOR:		EQUIPMENT:	

LOCATION		C.P. VALUE					PHOTO #	VIDEO #	DRAWING #	COMMENT #
		PIPELINE	ANODE	VALVE	FLANGE	OTHER/DESC.				

COMMENTS:

LOCATION	FIELD JOINT #	DISTANCE ALONG JOINT	SAMPLE PIPELINE CAIRS
CODE	SURVEY FIX #	SEA MARK	

ANODE SURVEY	INSPECTION #	PIPELINE ID #	DATE
DRAWING NO.			

LOCATION		TYPE (ORIG/RET)	CURR. DEN. (IBS.)	C.P. VALUE	DIMENSIONS (MAX/MIN)			EST. % DEPLTN	EST. REMAIN LIFE	PHOTO #	VIDEO #	DWG. #	COMM #
					L	W	H						

COMMENTS:

LOCATION	FIELD JOINT #	DISTANCE ALONG JOINT	SAMPLE PIPELINE CAIRS
CODE	SURVEY FIX #	SEA MARK	

BOTTOM EXPOSURE SURVEY	INSPECTION #	PIPELINE ID #	DATE
DRAWING NO.			

LOCATION		% EXPOSED	SCOUR (FT)	DEPOS. (FT)	DEPTH (T.O.P.)	DEPTH (NAT'L BOTT)	BOTTOM TYPE	PHOTO #	VIDEO #	DWG. #	COMM. #

COMMENTS:

LOCATION	FIELD JOINT #	DISTANCE ALONG JOINT	SAMPLE PIPELINE CAIRS
CODE	SURVEY FIX #	SEA MARK	

DEBRIS	INSPECTION #	PIPELINE ID #	DATE

LOCATION		DEBRIS DESCRIPTION	DIMENSIONS			DIST. FROM PIPE (FT)	SIDE OF PIPE	DAM-AGED (Y/N)	REM-OVED (Y/N)	C.P. VALUE	PHOTO #	VIDEO #	DWG. NO.	CMMNT #
			L	W	H									

COMMENTS:

LOCATION	FIELD JOINT #	DISTANCE ALONG JOINT	SAMPLE PIPELINE CAIRS
CODE	SURVEY FIX #	SEA MARK	

PHOTO LOG	INSPECTION #	PIPELINE ID #	DATE

LOCATION		ROLL #	FRAME #	INSPECTION CLASS	DESCRIPTION

LOCATION	FIELD JOINT #	DISTANCE ALONG JOINT	SAMPLE PIPELINE CAIRS
CODE	SURVEY FIX #	SEA MARK	

VIDEO LOG	INSPECTION #	PIPELINE ID #	DATE
TAPE TYPE		TAPE #	

LOCATION		TAPE COUNT	QUALITY 1=EXCELLENT 4=POOR	INSPECTION CLASS	COMMENTS

LOCATION	FIELD JOINT #	DISTANCE ALONG JOINT	SAMPLE PIPELINE CAIRS
CODE	SURVEY FIX #	SEA MARK	

GENERAL COMMENTS	INSPECTION #	PIPELINE ID #	DATE

		PHOTO NO.	VIDEO NO.	INSPECTION CATEGORY	DRAWING NO.

COMMENTS:

		PHOTO NO.	VIDEO NO.	INSPECTION CATEGORY	DRAWING NO.

COMMENTS:

		PHOTO NO.	VIDEO NO.	INSPECTION CATEGORY	DRAWING NO.

COMMENTS:

		PHOTO NO.	VIDEO NO.	INSPECTION CATEGORY	DRAWING NO.

COMMENTS:

LOCATION	FIELD JOINT #	DISTANCE ALONG JOINT	SAMPLE PIPELINE CAIRS
CODE	SURVEY FIX #	SEA MARK	